Water Column and Sediment Toxics Assessment and Management Issues for the Sacramento River Watershed

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A brief review of the some of the issues that should be considered in developing a water quality/sediment quality management program for "toxics" in the Sacramento River Watershed is presented below.

Reliability of Chemically-Based Aquatic Toxicity Estimates

- The exceedance of chemical specific water quality criteria/standards for potentially toxic chemicals is not reliable for estimating aquatic life toxicity due to the chemical.

- Aquatic life toxicity and excessive bioaccumulation cannot be reliably assessed by measuring the concentrations of chemical constituents in water. At best, chemical concentrations can only be used to indicate that certain regulated chemicals are present in a water at concentrations that under worst case conditions would be toxic to some forms of aquatic life in some waterbodies.

Chemical approaches for estimating aquatic life toxicity do not address:

- the toxicity or bioaccumulation of unregulated chemicals and combination of chemicals,

- the aqueous environmental chemistry of potential toxic chemicals that detoxifies chemical constituents in the Sacramento River system.

In addition to the attached paper, "Evaluation of the Water Quality Significance of the Chemical Constituents in Aquatic Systems: Coupling Sediment Quality Evaluation Results to Significant Water Quality Impacts," Lee and Jones-Lee (1995a, 1996a) "Appropriate Use of Numeric Chemical Concentration-Based Water Quality Criteria" and Lee and Jones-Lee (1993a) "Sediment Quality Criteria: Numeric Chemical- vs. Biological-Effects-Based Approaches" provide additional information on the unreliability of chemically-based approaches for estimating toxicity in waters and sediments.

Assessment of Aquatic Toxicity

- Toxicity should be assessed by using several sensitive forms of aquatic life at several time during the year. The spacial and temporal extent of toxicity should be assessed. It is

inappropriate to assume that toxic response measured in a laboratory test is of water quality significance in the Sacramento River system.

Assessing the Water Quality Significance of Aquatic Toxicity

- The determination of the water quality significance of measured aquatic life toxicity should be evaluated by an expert panel using a non-numeric best professional judgement (BPJ) weight-of-evidence approach. In order to be of water quality-use impairment significance, the toxicity must be of sufficiently persistence and extent to significantly adversely impact the numbers, types and characteristics of desirable forms of aquatic life of concern to the public.

- If potentially significant aquatic life toxicity is found in a region, then aquatic organism assemblages studies should be conducted over a least one year in the fall and spring to determine if the numbers, types and characteristics of desirable forms of aquatic life are adversely impacted in the region where toxicity is found.

Assessing Excessive Bioaccumulation

- The assessment of excessive bioaccumulation of potentially hazardous chemicals such as mercury, chlorinated hydrocarbon pesticides, PCB's, dioxins and other chemicals must be based on measurement of excessive concentrations in aquatic organism edible tissue that cause a perceived human health hazard when the organism is used as food. Also, as wildlife-based water quality criteria are developed, the presence of excessive concentrations in the whole organism should be assessed relative to these criteria if the organisms that the criteria are designed to protect are present in the watershed and use the organisms of concern as food.

- It should not be assumed that all forms of a potentially bioaccumulatable chemical such as mercury from a particular are in a form or will be converted into a chemical form that is bioaccumulatable. The control of a potential source of a bioaccumulatable chemical should be based on the finding that that source is a source of available forms of the chemical that actually accumulates in aquatic organisms to cause a health hazard.

Base Watershed-Based Water Quality Evaluation and Management Programs on Good Science and Engineering

- The aqueous environmental chemistry and toxicology of chemical constituents of potential concern due to toxicity or bioaccumulation should be appropriately incorporated into a water quality/sediment quality evaluation in order to avoid overregulation and the waste of public funds in unnecessary treatment/control programs beyond that needed to protect the designated beneficial uses of the Sacramento River and downstream waters. Additional information on incorporation of aquatic chemistry and aquatic toxicology is provided by Lee and Jones-Lee (1996b) "Aquatic Chemistry/Toxicology in Watershed-Based Water Quality Management Programs." Also as they

discuss, it is important to consider both nearfield (near the point of discharge-runoff) and farfield (downgradient) impacts of chemical constituents on water quality within a watershed.

Technically Valid Approach for Developing Toxics Control in the Sacramento River Watershed

- The focus of the Sacramento River Toxics Management Program should be on **toxicity** not chemical constituents that are under worst case conditions are toxic to some forms of aquatic life in some waterbodies.

- Since the funds available for the monitoring part of the SRWTCP are limited, it is essential that first priority be given to finding real, significant toxicity and bioaccumulation problems in the Sacramento River Watershed. Focusing the SRWTCP monitoring on continued measurement of heavy metals, pesticides and/or other organics provides more data of the type that already exits which shows that there are some exceedances of overly protective water quality criteria/standards (objectives). However, no information is provided in these types of monitoring programs whether these exceedances represent real, significant aquatic life toxicity.

  Further, chemical measurements diverts funds needed to assess whether real water quality problems-use impairments exit in the Sacramento River Watershed. This diversion of funds could jeopardize the success of the SRWTCP in developing the information needed to manage real toxics problems in the watershed.

- The SRWTCP monitoring should first be focused on screening the Sacramento River and its tributaries for aquatic life toxicity and excessive bioaccumulation. Where toxicity and/or excessive bioaccumulation is found, efforts should be devoted to assessing whether the toxicity and/or bioaccumulation is significant cause of water quality-use impairment.

The SRWTCP should adopt an "evaluation monitoring" approach of the type described by Lee and Jones-Lee (1996c) which focuses on finding real water quality problems due to toxics in the Sacramento River Watershed and/or downstream, identifying their cause, determining the source of the constituents that cause the problems and develop a control programs that focuses on source control.

- Since chemical measurements are unreliable for real water quality problem identification they should only be used to evaluate the potential cause of measured toxicity as part of a TIE.

- The analytical methods that should be used for toxicity as well as chemical measurements are in general the US EPA standard methods. All sampling and measurement methods should use "clean techniques" of the type recommended by the US EPA. For potentially toxic and bioaccumulatable chemicals, the analytical method used must be able to reliable measure the concentration of the chemical of concern at least 0.5 times the US EPA "Goldbook" or US EPA updated criterion values for the chemical.

Heavy Metals

- Some parts of the Sacramento River Watershed are experiencing water quality problems due to heavy metals. This is of particular importance in areas of acid mine drainage. Potentially toxic heavy metals such as Cu, Zn, Cd, Ni, Cr should be regulated based on toxic forms in the ambient waters and sediments. These forms can not be estimated by chemical measurements. Generally, even properly measured dissolved forms overestimate the toxic forms of the metal.

Not only must the toxicity of the metal be measured in the discharge and at the point of discharge in the receiving waters, also toxicity measurements must be made downstream of the discharge to be certain that the non-toxic forms do not convert to toxic forms to cause toxicity. Of particular importance is that some regulatory agencies (CVRWQCB) allow the discharge of Cr(III) at 50 μg/L when the US EPA revised ambient water toxicity based limit for Cr(Vl) is 10 μg/L. Chromium Cr(lll) is well known to convert to Cr(VI) under conditions that exits in surface waters. This problem is of particular concern in the waterbodies where the flow in the receiving is primarily the wastewater discharge.

- Mercury and selenium are regulated based their potential to bioaccumulate in higher trophic level organisms that represent threats to higher trophic level organisms that use lower trophic levels as food. Mercury is the cause significant water quality problems within and downstream of the Sacramento River system. It is important that the source(s) of the mercury that bioaccumulate in organisms in various part of the watershed and downstream become better understood.

- Selenium is of concern because of bioaccumulation that is adverse to waterfowl reproduction. While this problem has been found in San Joaquin Valley wetlands, it is also of potential concern in the San Francisco Bay area due to wastewater discharges of selenium. There is need to evaluate whether selenium is a cause water quality problems in the Sacramento River system.

- At this time arsenic is not considered a significant cause of water quality problems in the Sacramento River system. However, there is growing understanding that arsenic is a potentially significant carcinogen in domestic water supplies. The US EPA has proposed to reduce the acceptable arsenic concentrations in domestic water supplies to a 20, 2, or 0.2 μg/L. Adopting one of the lower proposed regulatory levels would cause some of the surface and groundwaters in the Sacramento River system to be considered hazardous for use as a domestic water supply without treatment for arsenic removal. The arsenic is derived from natural sources as well as the activities of man. There is need to monitor arsenic concentrations in surface and groundwaters to about 1 μg/L in anticipation of pending regulatory requirements.

Pesticides and Related Compounds

- Organophosphorus pesticides used by agriculture and in urban areas cause significant acute aquatic life toxicity in the Sacramento River Watershed. There is need to better understand the water quality significance of the high levels of organophosphorus pesticides caused toxicity that occurs in the Sacramento River system.

- At this time there has been inadequate evaluation of pesticides, herbicides and other related chemicals as a cause of chronic toxicity to aquatic life in the Sacramento River Watershed and Sacramento River San Joaquin River Delta.

- Chlorinated hydrocarbon pesticides, PCB's, dioxins are important causes of excessive bioaccumulation in the Delta and in San Francisco Bay. It is unknown if the Sacramento River Watershed is still an important source of the chemicals that are accumulating to excessive amounts in San Francisco Bay. Also there is need to review the data of the WRCB Toxic Monitoring Program to assess if fish and other aquatic organisms in the Sacramento River system are bioaccumulating excessive amounts of hazardous chemical. If there is insufficient recent data to properly characterize the current degree of bioaccumulation in Sacramento River system organisms, it may be necessary to collect additional bioaccumulation data on key organisms in the system that are used for human food.

- Copper is used as a pesticide in orchards and possibly on others crops. Because of the potential for high levels of aquatic life toxicity due to chemicals that are used as pesticides, fungicides and herbicides, the SRWTCP should include a specific effort devoted to determining what pesticides *et al.* that are used in the watershed, where and the amount used, the fate of the pesticides *et al.* and measurement of toxicity in runoff waters and in atmospheric transport from the areas where it is applied. This cataloging of pesticide use should be an ongoing effort to try to detect pesticide aquatic life toxicity problems before them become widespread and significant.

Nitrogen and Phosphorus Compounds

- Nitrogen compounds cause aquatic life and human health toxicity problems in the Sacramento River Watershed. There are highly significant water quality problems due to nitrate pollution of groundwater by agriculture fertilization practices and waste wastewater disposal that lead to pollution of groundwaters above the nitrate drinking water standard (MCL) of 10 mg/L NO_3^--N.

Un-ionized NH_3 is highly toxic to several forms of aquatic life of importance to water quality. There are situations in the Sacramento River system where NPDES permitted wastewater dischargers discharge ammonia in sufficient amounts to cause un-ionized NH_3 toxicity in the receiving waters. Ammonia toxicity problems are usually nearfield problems that occur near the point of wastewater discharge.

- The current approach used in establishing the aquatic life toxicity monitoring associated with NPDES permitted discharges is inadequate to reliably detect ambient water toxicity due to the chemicals in the discharge for some permitted discharges. NPDES permits issued in the Sacramento River system should include quarterly measurement of ambient water chronic toxicity near the point of wastewater discharge and downstream to evaluate whether the discharge of regulated and unregulated chemicals alone or in combination with others chemicals in the upstream ambient waters are significantly toxic to aquatic life.

- Nitrogen and phosphorus compounds used in agriculture and/or discharged in the Sacramento River watershed cause toxicity to humans and aquatic life in the Sacramento River Watershed and downstream of the watershed. This toxicity is the result of the nitrogen compounds (nitrate, nitrite, ammonia and organic nitrogen) and phosphorus compounds principally orthophosphate, condensed inorganic phosphate and some organic phosphorus that stimulate the growth of algae and other aquatic plants. As discussed in the inclosed preprint of the paper, "Evaluation of the Water Quality Significance of the Chemical Constituents in Aquatic Systems: Coupling Sediment Quality Evaluation Results to Significant Water Quality Impacts" that when the algae and other plants die they consume dissolved oxygen which leads to low DO in the sediments. The low DO in the sediments leads to the accumulation of H_2S and NH_3 which are highly toxic to benthic and epibenthic organisms associated with the sediments.

The growth of algae and many other aquatic plants is controlled by the amount of algal available N & P compounds added to the waterbody. Agriculture drainage and runoff, urban areas stormwater runoff and domestic wastewaters discharged to the Sacramento River and its tributaries are the primary sources of these nutrients.

In addition, algae and other aquatic plants cause deteriorated water quality through aesthetic impairment of recreation uses. This type of problem is becoming highly important in the Delta due to aquatic weed growth.

The algae and other plants that develop due to the discharge N & P compounds to the Sacramento River and tributaries also contribute to domestic water supply water quality deterioration through taste and odors, shortened filter runs and most important contribute to the trihalomethane (THM) precursors. THM's are the result of chlorination of water supplies where the chlorine reacts with dissolved organic carbon (DOC) (THM precursors) derived from terrestrial and aquatic plants that is present in irrigation drainage and runoff waters, urban area stormwater runoff and domestic and industrial wastewater discharges.

THM's are of public health concern because of they are regulated as human carcinogens. MCL's have been established for several of the THM's such as chloroform. The US EPA will soon revise downward the THM drinking water standard and will release several new MCL's for newly recognized THM's. The Agency will also soon require that DOC in a domestic water supply be controlled to reduce the THM content of treated drinking water.

Lee and Jones (1991a,b) have discussed the algal nutrient-domestic water supply water quality issues in the Delta. They report that significant water quality problems are occurring that are due to the discharge of THM precursors and aquatic plant nutrients to the Sacramento River San Joaquin River systems. There is need to better understand the sources of DOC that leads to increased THM's in domestic water supplies in the Sacramento River system and downstream.

Therefore, the fertilizers used on land that result in runoff that contains increased DOC as well as nutrients (N & P) present in rural and urban storm water runoff and wastewater discharges in the Sacramento River Watershed leads to "toxicity" to human through production of potential carcinogens (THM's). In addition, as discussed by Lee and Jones-Lee (1996d) the growth and death of algae and other plants leads to low dissolved oxygen and the associated H_2S and NH_3 in Sacramento River system and downstream sediments. The N & P derived toxicity causes sediment toxicity in many parts of the Sacramento River Watershed and downstream such as in the Delta and San Francisco Bay. The water quality significance of this toxicity is not understood at this time.

Pathogenic Organisms

- The SRWTCP stakeholders have defined "toxicants" as any constituent that is adverse to public health and the environment. This definition includes pathogens that impact the sanitary quality of water for use in domestic water supplies and for contact recreation. Lee and Jones-Lee (1993b, 1994, 1995b,c) have reviewed the public health significance of bacteria, enteroviruses and cyst forming protozoans as a cause of human disease through water supplies and contact recreation. The 1993 Milwaukee *Cryptosporidium* incident in which 400,000 people became ill and about 100 people died due to *Cryptospordium* that passed through conventual domestic water supply treatment has prompted widespread review and investigation waterborne pathogens in surface waters that are a threat to domestic water supplies and those who contact recreate in these waters. In addition to domestic wastewaters being a source of these pathogenic organisms, certain agricultural and animal husbandry activities such as dairies and feedlots contribute *Cryptospordium* to surface waters.

At this time the sources, occurrence and water quality significance of waterborne pathogens in the Sacramento River Watershed is poorly understood. This is an area that needs attention as part of the SRWTCP. There is need to expand the sanitary quality monitoring program to include more comprehensive coverage of domestic water supply watersheds, contact recreation areas and public health risk of contact recreation in the Sacramento River system. The sanitary quality monitoring program should include total and fecal coliforms, E. coli, fecal streptococcus, enteroviruses-bacterial phages, Cryptospordium and Guardia at quarterly intervals during the fall, winter and spring and monthly during the contact recreation period.

Groundwater Quality Protection

While surface water toxicity is the focus of the SRWTCP, because of the importance and intercoupling of surface and groundwaters in the watershed, it is important to protect the quality of groundwaters resources in the watershed.

- At this time groundwaters are not being protected from pollution by hazardous and deleterious chemicals present in solid wastes that are managed by landfilling. While current regulatory requirements prohibit groundwater pollution by landfills, inactive and active municipal and industrial landfills and other waste disposal areas are polluting groundwaters with leachate that contains highly hazardous and deleterious chemicals. Further, landfills are being permitted today that will at best only delay when groundwater pollution occurs. There is inadequate enforcement of current WRCB Chapter 15 regulatory requirements which require that landfills be designed, constructed, operated, closed and maintained during the post-closure period so that no pollution of groundwaters occur for as long as the wastes in the landfill are threat. There is need to improve the implementation of current regulatory requirements.

Widespread pollution of groundwaters has occurred and is occurring by nitrogen fertilizers (nitrate) possibly by pesticides and other hazardous chemicals associated with agricultural activities. The current regulatory requirements are highly ineffective in preventing the pollution of groundwaters by agricultural activities. There is need to require that all users of nitrogen fertilizers and other agricultural chemicals monitor the groundwaters that could be impacted by fertilizer - chemical applications to detect potential groundwater pollution.

Because of the highly significant threat that the agricultural use fertilizers and other chemicals represent to public health through pollution of groundwaters and the importance of the groundwaters in the Sacramento River system to the region and the state, regulatory programs should be developed and most importantly implemented and enforced to stop further groundwater pollution. Particular attention should be given to controlling agricultural activities, municipal and industrial solid and liquid waste disposal. Failure to develop and implement these programs will result in continued groundwater in the Sacramento River system.

Additional Information

Additional information on these issues as applied to the Sacramento River system is available upon request.

References

The references listed below serve as backup to this discussion. A copy of them is available for the authors upon request.

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